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Grand Staircase –Escalante National Monument

Highlighted Objects & Research

Understanding the History of Humans In the Region

Hole-in-the-Rock Trail - Significant site in Utah History associated with the 1879-1880 mission that took the first permanent settlers to San Juan County from many southern Utah communities. The trail and associated road building is likely one of the best examples of pioneer spirit including ingenuity, tenacity, and courage. The site is listed on the National Register of Historic Places (in 1980). A 2017 Ethnographic Landscape Report was prepared by NPS leading towards considering the trail and its associated places (such as Hole-in-the-Rock, Dance Hall Rock, and the many temporary camps) as a Traditional Cultural Property.

Dance Hall Rock – A large natural bedrock exposure that is a major landmark along the Hole-in-the-Rock Trail. This location was used by the Hole-in-the-Rock expedition as a social focal point during the construction of the trail through Hole-in-the-Rock and down to the Colorado River. Dances were held at this location during this period in 1879-1880 while pioneers were camped a mile away at Forty Mile Spring. There are numerous inscriptions of the members of the expedition carved into this landform.

Old Paria Townsite – While early settlement occurred in the region from 1869-1885, people lived in the area until the mid-1930s. The landscape today is relatively unchanged from modern development. The major alteration of the landscape is a result of the flooding of the Paria River through the years. This helps illustrate the history of the area and why settlement failed.

Southern Paiute and Navajo Peoples – Used this area extensively and have reservations near by. In 1934 Isabel Kelly wrote a Southern Paiute ethnography of the area describing Southern Paiute lifeways in this area including areas around Kanab, Kitchen Corral Canyon, and the Kaiparowits. This publication has been a guiding reference for current graduate student research in ethnobotany and Native American spring/water use on the Monument. Southern Paiute people still use many places on the Monument for collection of natural resources. There is some use of the area by Navajo peoples including a 1860s camp in vicinity of White House Campground. This general area, including Catstair Canyon is still used as by Navajo peoples for plant collection.

Mormon Exploration and Settlement - Important to the settlement of this area and to Utah history, there are numerous homesteads, ranches, and early settlements located on the Monument and in the surrounding area. Additionally, there are a number of wagon trails and early automobile trails connecting these places as well as line camps, cattle trails, corrals, cabins, rock houses, and other manifestations related to the early livestock grazing that occurred in association with settlement.

Historic Trails, Inscriptions – Hole-in-the-Rock Trail (see above) is listed on the National Register of Historic Places. The Old Spanish Trail is a National Historic Trail that roughly parallels Hwy 89 on the Grand Staircase. Many other trails, including the Boulder Mail Trail from Escalante to Boulder and Old Paria Road from Johnson Canyon to Paria River, are associated with Mormon exploration and settlement.

Opportunities for Archaeological Research – Academic research has occurred in this area since perhaps around 1890. University of Utah did a lot of research on the Kaiparowits and Escalante Canyons area associated with the construction of Glen Canyon Dam in the 1950s and 60s.

Steward did early research in the Anasazi area of the Vermillion Cliffs in the 1930s. BYU has done a lot of research in the Escalante Region in the late 1990s and early 2000s. Current graduate research within the past 5 years has included paleoecological analysis of the both the Grand Staircase and Kaiparowits regions, rock art research, and ethnobotanical studies. Research potential and opportunities are of plenty. A BLM Utah Cultural Resource Series No. 28 text titled "Formative Chronology and Site Distribution of the Grand Staircase-Escalante National Monument" (2016) provides a definitive cultural chronology for the area.

Fremont-Anasazi Occupation – Fremont occupation occurred along the Escalante River corridor and Potato Valley (Escalante area) and continued onto the Kaiparowits and Aquarius Plateaus from 300 BC to circa 1300 AD. Anasazi occupations (500 BC to 1300 AD) occurred on the Grand Staircase along the Vermillion Cliffs and up canyons (Johnson Canyon, Kitchen Corral Canyon, Paria River, Wahweap Creek, etc) as well as certain places on the Kaiparowits Plateau. Interactions between the Fremont and the Anasazi occurred on the Kaiparowits Plateau (particularly Fifty Mile mountain and the Straight Cliffs areas and Escalante Canyon, and probably also around Wahweap Creek (more research needs to be done). Fremont and especially Anasazi had large populations of people living in this area particularly from 900 AD to 1300 AD.

Geologic Structures, Stratigraphy, and Erosional Features

The Grand Staircase (Paleozoic) -- An unbroken, well-exposed, sequence of cliffs and plateaus of through Tertiary sedimentary rocks that rise 5,500 feet from the Chocolate Cliffs to the rim of Bryce Canyon. *"The most colorful exposed geologic section in the world."* - H.H. Doelling. This physiographic region was the centerpiece of classic geological studies by Powell, Stanton, Dutton, Walcott, Thompson, and others and has become symbolic of early geologic exploration on the Colorado Plateau (Titus, 2013). The Vermillion Cliffs in particular contain a rich Late Triassic-through early Jurassic fossil record deposited on the eastern shores of ancient Lake Dixie. Petrified wood, fish remains, dinosaur and other reptilian bones and fossil footprints are common (Fox and Joyce, 200?). One site in particular, the Flag Point tracksite (42KaNNNN) is probably worthy of world heritage designation as the fossil tracks are in direct association with a unique Native American rock art panel depicting dinosaur tracks. The area has become a popular ATV riding destination as it contains a segment of the Great Western Trail and also numerous trails along the Wygaret and Skutumpah terraces. Hiking is also popular in the particularly deep and long slot canyons hosted in the Navajo Sandstone such as Willis Creek, Bull Valley Gorge, and Lick Wash.

The Upper Paria Region – Rugged canyons, natural arches, and "hydrothermal-collapse" pipes and dikes. The Upper Paria River region contains more of the same geologic and scenic features found inside Kodachrome Basin State Park. The middle Jurassic rocks (Carmel and Entrada formations) exposed there are particularly colorful and varied. The collapse features are part of a fascinating story of geologic catastrophe, being triggered by either a massive earthquake or asteroid impact.

White Cliffs -- Exposure of more than 1,500 vertical feet of eolian (wind-deposited), Jurassic Navajo Sandstone. This formation is world renowned for its scenic beauty. It is actually the remains of the largest sand sea (erg) that ever existed and thus is geologically unique. However, the formation is widespread on the Colorado Plateau region and is the centerpiece of such scenic wonders such as Zion, Arches, and Capitol Reef national parks.

Vermillion Cliffs -- Jurassic Moenave and Kayenta Formations of near-shore marine origins. The Moenave and Kayenta formations are actually river, dune and lake deposits that accumulated far from any marine shoreline. The upper portion of this sequence is a common arch former and thus of scenic value, while the cliffs themselves are particularly scenic with their deep red hues. The layers date to the early Jurassic and record a major extinction and the ascendancy of the dinosaurs in North American ecosystems. The most common fossils are fossil footprints and invertebrate

traces.

Kaiparowits Plateau – Cretaceous, coal-bearing deltaic sequences deposited in a major depositional basin. Part of the coal field is burning underground from naturally ignited fires. The Burning Hills are evidence of past fires. The vast, wild, rugged badlands scenery of the Kaiparowits Plateau is comparable to that of the famous Bisti Badlands of New Mexico, both in character and color, but with more topographic relief. Overall the region is characterized by gray colors and towering cliffs separating tiers of fossil-rich badlands (see below under Paleontological Resources). Coal resources are mostly confined to the eastern half, where the conditions were more persistently swampy. In these areas, coal fires such as are found in the Burning hills provide a rich veneer of red and orange color where the rocks have oxidized. Most of the formations locally weather into intricate scenic hoodoos. Several routes through the region such as the Smoky Mountain road, Collett Canyon, and Croton Canyon are popular with OHV users. The “otherworldly” scenery of the Kaiparowits is also popular with advertisers and film companies and several large budget movies such as “Planet of the Apes,” “John Carter of Mars,” “The Outlaw Josey Wales,” and “Evolution,” have been filmed in and around the Kaiparowits over the last four decades. Although typically not a “hiking destination” the ever increasingly popular Heyduke Trail now traverses the northern half of the Kaiparowits Plateau.

Straight Cliffs – These cliffs are a series of stacked, Cretaceous barrier islands. The Straight Cliffs are so named because the cliffs themselves mimic the Cretaceous shoreline. UPDATE: The Straight Cliffs topographic feature is formed in the Straight Cliffs Formation of Cretaceous age. The scenic cliffs are a prominent regional land form and define the eastern edge of the Kaiparowits Plateau. Some of the most significant archeology in the entire monument is found on its southern end.

The Cockscomb – An impressive, erosional “hogback” developed along the East Kaibab monocline. The East Kaibab monocline is the steeply dipping east limb of the Kaibab anticline. The Cockscomb is one of the Monument’s true scenic wonders. It is a large scale ridge formed by the resistant geologic layers caught up in the large scale folding of the East Kaibab Monocline, which continues into Arizona and defines the east edge of the Grand Canyon. The stark uplift, broad exposures of multicolored rocks and intricate canyons carved into it create a feature comparable in wonder and beauty to that of Capitol Reef National Park, Comb Ridge, or The San Rafael Swell. It is extremely popular with tourists, many of which drive the busy Cottonwood Canyon road. Popular destinations include the Paria Townsite and Josey Wales movie set, Hackberry Canyon, The Box, Cat Stair Canyon, The Squeeze, the Cottonwood Narrows (most accessible slot canyon in the Monument), Grosvenor Arch, The Gut, and the Brigham Plain road.

Circle Cliffs – A breached anticline which exposes sedimentary rocks of the Triassic Chinle and Moenkopi formations that contain large, unbroken petrified logs, uranium minerals, and bitumen deposits. The Circle Cliffs contains spectacular Colorado Plateau scenery of painted-desert badlands and sandstone cliffs. Numerous Cold War era uranium mines that were hosted in the Shinarump Member of the Chinle Formation are popular as tourist destinations. Hiking is popular in many of the canyons that lead into the Escalante River drainage. Rock climbing has become a popular activity on vertical exposures of the Wingate Sandstone, especially along Long Canyon on the Burr Trail.

Waterpocket Fold – A long, sinuous geologic fold and erosional expression, similar to The Cockscomb, comprising the east flank of the Circle Cliffs anticline. The Waterpocket Fold is the same exact feature found in Capitol Reef National Park, with which GSENM shares a common boundary. Its world class scenery and rugged remoteness are popular with wilderness seekers.

Natural Arches and Bridges – Escalante Natural Bridge, Grosvenor Arch, Starlight Arch, Woolsey Arch, Window Arch, Boyington Arch, Phipps Arch, Sunset Arch. The Monument’s arches and natural bridges, with Grosvenor Arch and those exposed along the Escalante River corridor are

continually increasing in popularity as tourist destinations. Grosvenor is a rare double arch which towers over 150 feet high.

Canyon Exposures – Vivid colors of the Escalante Canyons region and elsewhere cause by intense erosion and downcutting (no opportunity for soil forming) of the many Mesozoic sedimentary rocks units. These exposures provide geologists with unobscured views of Earth history. The Escalante Canyons region is the single most visited area within GSENM. An abundance of slot canyons, towering cliffs, scenic red rocks, and lush riparian areas combine to make it one of the most beautiful and popular areas in the entire region. Recent geological studies in the area have sought to establish the rates of erosion, and the chemical and migration history of iron minerals that provide the color to the rocks (Chan and Beitler NNNN).

World-Class Paleontological Sites

Circle Cliffs – Unbroken petrified logs up to 30 feet in length are present in the Petrified Forest Member of the Chinle Formation. Survey work by Yale between 2002-2006 documented a number of important vertebrate fossil sites in the Chinle Formation in the Circle Cliffs region including a nearly complete articulated rare reptile called *Poposaurus* (<http://peabody.yale.edu/support/peabody-finds-poposaurus>). The region has not been the focus of much additional survey work since 2006 and numerous additional sites probably still await discovery.

Kaiparowits Plateau – One of the best, most continuous records of Late Cretaceous life in the world. Fossils include mollusks, reptiles (turtles, crocodilians, lizards), dinosaurs, fishes, and mammals. The Kaiparowits rocks contain the only evidence, in our hemisphere, of terrestrial vertebrate fauna from the Cenomanian through Santonian (Late Cretaceous) ages

The Cretaceous age fossil resources of the Kaiparowits Plateau have exceeded the Proclamation's expectations both in terms of abundance and scientific significance. Almost 4,000 new fossil sites have been documented by Museum and University crews under the coordination of the Monument's paleontology program since 2000. All formations have yielded vertebrate fossils, but Tropic Shale, Wahweap, and Kaiparowits fossils have been most spectacular and significant. Scientific work on these fossils has resulted in the publication of 12 new species of dinosaurs in the last 12 years, a pace on par with any other dinosaur producing region in North America. A Kaiparowits specific conference on late Cretaceous paleontology was held in 2009, which resulted in the publication of a 625 page book called "At the Top of the Grand Staircase: The Late Cretaceous of Southern Utah" (Titus and Loewen, 2013). Because of its unique ancient geography and environments, the region remains the most complete, most fossiliferous Late Cretaceous terrestrial fossil record in the western hemisphere. They were also recently showcased during an international meeting on vertebrate paleontology held in Salt Lake City (Titus, Eaton, and Sertich, 2017).

The Cretaceous formations of the Kaiparowits Plateau are, in ascending order with their significance summarized:

- **Dakota Formation** – Important early mammal and reptile fossils. Contains one of the only terrestrial vertebrate fossil records in North America. The Bulldog Bench and Rimrocks (lower Cottonwood Canyon) areas are especially rich. Larger remains are rare, but intact turtle shells, and pieces of crocodiles are fairly common. Dinosaurs are still only known by tooth records. The mammal, fish, amphibian and lizard faunas were published in Titus and Loewen (2013). Surveys by Weber State and the Natural History Museum of Utah are ongoing.
- **Tropic Shale Formation** – Best marine reptile record from the southern Interior Seaway.

Inventory work has shown that a truly remarkable marine reptile record is in the Tropic. Five species of plesiosaur (whale-size marine reptiles) and North America's oldest mosasaur were found between 2000 and 2010. This is the highest diversity known for the period in North America. Many acres remain to be surveyed, particularly in the Croton Canyon and Steer Canyon areas.

- **Straight Cliffs Formation** – Tippet Canyon member-The Tippet Canyon has been intermittently surveyed in the southwestern portion of the Kaiparowits Plateau where it contains fossil sharks teeth, turtle shell and rare dinosaur remains. It is mostly marine in the eastern half of the Kaiparowits, where it lacks an abundance of vertebrate fossils. Spectacular logs of petrified wood occur east of Cottonwood Canyon. No new animals have been named from the unit.
- **Smoky Hollow and John Henry members** -Two small dinosaur bonebeds were found in the Smoky Hollow member in 2009 during survey work in the southwestern Kaiparowits Plateau. These are some of the only records of Turonian dinosaur skeletons in Utah. The John Henry member has yielded associated tyrannosaur material and other rare dinosaur finds in the same area. Dinosaur remains from the time of the John Henry Member are extremely rare throughout the whole world and any material is considered significant. No dinosaurs have been named from the Straight Cliffs formation thus far. The mammal, turtle, fish and lizard faunas of these two units was published in Titus and Loewen (2013).
- **Wahweap Formation** – The exact age of the Wahweap Formation was unknown when the Monument was established. Research has since shown that the unit dates to between 78 and 81 million years ago. The most fossiliferous part of the formation (middle shale member) has produced a spectacular dinosaur fauna that is older than similar faunas found in Montana and Canada (Titus, Eaton, and Sertich, 2017). In general, the western outcrops are more fossiliferous than those in the east. Five new species of dinosaurs (*Diabloceratops eatoni*, *Machairoceratops cronusi*, *Adelolophus hutchisoni*, *Acristavus gaglarsoni*, *Lythronax argestes*) have been named, with two more and a giant crocodile currently being researched. A rich fossil record has yielded important specimens of everything from fish to mammals and plants (Titus and Loewen, 2013). It is one of the most complete known middle Campanian ecosystems preserved in North America and gives key insights into the evolution of later, more famous Campanian species. Survey work in the formation is still in its early stages, with only an estimated 10% of available exposures having been covered.
- **Kaiparowits Formation** – This formation has long been known to be the most fossiliferous formation in the region and it has been the focus of most recent survey work. New species of dinosaurs were discovered the very first field season (2000) by crews from the Natural History Museum of Utah and almost every year since. In total seven new species (*Hagryphus*, *Gryposaurus monumentensis*, *Nasutoceratops titusi*, *Kosmoceratops richardsoni*, *Utahceratops gettyi*, *Teratophoneus curriei*, *Talos sampsoni*) have been published. A similar number will be published in the next few years, making it one of the most scientifically productive dinosaur resources in North America. Similar age beds in Canada have also provided a complete glimpse of this time period, but the Kaiparowits Formation is the most complete Late Campanian fossil ecosystem in the southern USA. Some of the literally world class finds include mass death assemblages of turtles, crocodiles and dinosaurs preserved with soft tissue and eggs; an entire tyrannosaur family killed by fire (only multi individual tyrannosaur site in the southern USA); an nearly complete articulated tyrannosaur (the only one ever found in the southern USA); and a fossil forest floor preserved with all of its plants in upright, 3D position. It is almost impossible to overstate the scientific importance of the this particular formation and its fossil content. Approximately 30% of the formation has been surveyed as of 2017.

Monument Wide – Although not specifically noted in the Proclamation, many opportunities for

paleontological research also exist in formations of the Permian, Triassic, Jurassic, and Tertiary periods.

Opportunities for Biological Research and Discovery

Five Life Zones – The life zones range from low-lying desert to coniferous forests containing a blend of warm and cold desert floras. This rich floristic region contains a large number of endemic species and three T&E plant species. Currently 979 plant species occur within the GSENM. For the past 10 years an active restoration program has restored rangeland health on approximately 25,000 acres. In addition, the noxious and invasive weed program has been under way to mitigate noxious and invasive weeds by rapidly detecting and responding to areas where weeds are found. One example is the Escalante River noxious and invasive weed program; one of the larger projects on the Monument to remove noxious species (i.e., Russian Olive and Tamarisk) from the riparian corridors and restore the native vegetation. Because of its rugged remoteness, the Monument contains many isolated biologic communities (hanging gardens, tinajas, rock crevices, canyon bottoms, and dunal packet communities).

Escalante River --The Escalante River is one of the last free-flowing small rivers in the Intermountain West. In June 2009 a partnership formed to coordinate riparian restoration efforts in southern Utah's Escalante River Watershed. The partnership, known as Escalante River Watershed Partnership (ERWP), is composed of agencies, local governments, organizations, businesses, non-profits, and individuals who live and work near or on the Escalante River. The Escalante River Watershed Partnership was selected as Utah's selection for the 2012 America's Great Outdoor Rivers. (<https://www.law.utah.edu/interior-secretary-selects-environmental-dispute-resolution-programs-project-selected-as-one-of-americas-great-outdoors-rivers/>)

Diverse Soils – An array of strata (parent material), exposed in many places, that give rise to diverse soils that support equally diverse plant communities and their pollinators. These communities offer opportunities to study plant speciation and community dynamics. BLM has incorporated a landscape monitoring approach called Assessment, Inventory, and Monitoring (AIM) to initially inventory soils and associated plant communities and then monitor these communities over time (Toevs et al., 2011). The AIM protocol incorporates a standardized set of core methods for vegetation and soil monitoring so that landscapes are statistically comparable across multiple scales.

Relic Vegetation -- Isolated because of topography, many areas contain relatively undisturbed plant communities - some of which may have existed since the Pleistocene. No Mans Mesa is an example where pinyon-juniper communities contain trees as much as 1,400 years old.

Cryptobiotic Crusts -- These crusts contain unique microbiotic communities that stabilize the highly erodible soils of the region.

Packrat Middens -- Provide insight into climate and vegetation over the past 25,000 years.

Livestock Grazing – The Monument has partnered with Utah State University for livestock grazing research opportunities.

Watershed Intactness – A study is underway to develop decision support tools for watershed management by taking a “step-down” approach to explore aquatic intactness using the Colorado Plateau—Rapid Ecoregional Assessment (COPL—REA). The case study is stepping down the COPL—REA to the Escalante River watershed, and incorporating other data, such as Aquatic AIM and geospatial approaches (e.g., Riparian vegetation models), to determine drivers of aquatic intactness in the watershed.

Wildlife Diversity – The proclamation highlights mountain lion, black bear, desert bighorn sheep, over 200 species of birds, peregrine falcon and bald eagle as some of the more iconic species

inhabiting the Monument. However, the Monument is also home to a prolific mule deer herd and a growing number of rocky mountain elk. Pronghorn and river otter have been reintroduced to the Monument since its creation. Highlights of introductions/augmentations, research and discovery are highlighted below:

- **Pronghorn Reintroduction and Research** – Between 1999 and 2005, over 400 pronghorn antelope were reintroduced on the Monument in the Kaiparowits region near Big Water. In 2012, 25 adult doe pronghorn were captured and fitted with GPS tracking collars. Over the course of over two years, the data gathered helped determine survival, reproduction and to map home ranges, and seasonal habitat use. Pronghorn are stable on the Monument.
- **River Otter** – River otter were reintroduced in Calf Creek, a tributary of the Escalante river. Otters are seen occasionally along the Escalante and as far south as Lake Powell.
- **Hummingbird** – GSENM is part of an international group of biologists conducting research on hummingbirds, the Hummingbird Monitoring Network. This network consists of hummingbird capturing and banding locations scattered throughout Mexico, the United States and Canada. GSENM bands hummingbirds at three separate locations during the months of April through September. Two species previously not known to occur on GSENM have been confirmed.
- **Mountain Lion** – GSENM partnered with USGS and Northern Arizona University to collaborate on a mountain lion study occurring throughout the Colorado Plateau. One male mountain lion was captured and fitted with a GPS tracking collar. Every kill made by the mountain lion was monitored over the course of nine months. Home range data was also determined by the study.
- **Desert Bighorn Sheep** – Bighorn sheep augmentations have occurred sporadically on GSENM. Over the past several years, over 200 bighorn sheep from Nevada have been released at various locations on the Monument. Many bighorn sheep were fitted with GPS collars prior to release. The GPS data has helped us to determine survival, dispersal, and home range data. Bighorn sheep are doing well on the Monument and their numbers continue to increase towards population objectives.
- **Black Bear** – GSENM has partnered with Brigham Young University to participate in a black bear study on the Paunsaugunt plateau. This past summer, six black bear were captured and collared as part of this study. Bears were fitted with GPS collars which will give us survival, home range, habitat use and reproduction data.
- **Mule Deer** – Thousands of mule deer from the Paunsaugunt plateau migrate long distances to wintering grounds on GSENM. Over the past decade, thousands of acres of winter habitat have been improved by removing encroaching pinyon and juniper trees as well as planting vegetation consumed by deer in winter months. Many water projects have also been completed to provide necessary water on these crucial wintering grounds.

In 2013, 13 miles of U.S. 89 received deer-proof fencing on both sides of the highway to prevent deer-vehicle collisions. Several underpasses were constructed to allow the deer to continue under the roadway and finish migrating to their winter grounds. Utah State University has been monitoring the success of this project and has verified that within two years, the vast majority of deer have been able to figure out the system of underpasses and complete their annual migrations.

Last winter, 40 mule deer does were captured and collared on their wintering grounds on GSENM. The purpose of this study is to collect home range, survival and migration data.

Preliminary data suggest that some of our deer travel 50 miles or more to winter grounds on GSENM.

- **Greater Sage-Grouse** – At the creation of the Monument, sage-grouse existed in low numbers on GSENM but were not a species of concern at that time. Recently sage-grouse have garnered much attention as their numbers range-wide have decreased dramatically and they were petitioned for listing. GSENM is home to the southern-most population of sage-grouse in their range. GSENM has partnered with two universities and the state of Utah to collar and monitor numerous sage-grouse in this area. The data has helped us to determine home ranges, seasonal habitat use, use of treated areas and survival.

Citations

Titus, A. L. and Loewen, M.A. 2013. At the top of the Grand Staircase, the Late Cretaceous of Southern Utah. Indiana University Press, Bloomington, 625 pages.

Titus, A.L., Eaton, J.G., and Sertich, J., 2016, Late Cretaceous stratigraphy and vertebrate faunas of the Markagunt, Paunsaugunt, and Kaiparowits Plateaus, southern Utah: Geology of the Intermountain West, v. 3, p. 229–291.

Toeve, G.R., J.W. Karl, J.J. Taylor, C.S. Spurrier, M.Karl, M.R. Bobo, and J.E. Herrick. 2011. Consistent Indicators and Methods and a Scalable Sample Design to Meet Assessment, Inventory, and Monitoring Needs Across Scales. Rangelands 33(4): 14-20.
